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## Facsimile Coding Schemes and Coding Control Functions for Group 4 Facsimile Equipment

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(From Standards Proposal No. 1814 formulated under the cognizance of EIA Engineering Committee TR-29 on Facsimile Systems and Equipment.)

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## FACSIMILE CODING SCHEMES AND CODING CONTROL FUNCTIONS FOR GROUP 4 FACSIMILE EQUIPMENT

### 1. General

#### 1.1 Scope

##### 1.1.1

This Standard (P/N 1814) defines the facsimile coding schemes, and their control functions to be used in the group 4 facsimile

##### 1.1.2

This Standard (P/N 1814) should be read in conjunction with the following Recommendations:

- T.5 - General aspects of Group 4 facsimile equipment (Equivalent to EIA P/N 1466);
- T.73 - Document interchange protocol for the Telematic service;
- T.62 - Control procedures for Teletex and Group 4 facsimile services (Equivalent to EIA P/N 1467);
- T.70 - Network-independent basic transport service for Telematic services;
- F.161 - International Group 4 facsimile service

In addition, in the case of Group 4 class 2/3 (Teletex or mixed-mode of operation), the following Recommendations should also be read:

- T.60 - Terminal equipment for use in the Teletex service
- T.61 - Character repertoire and coded character sets for the international Teletex service
- T.72 - Terminal capabilities for mixed mode of operation



## 1.2 Fundamental principles

### 1.2.1 Facsimile coding schemes and coding control functions

- (1) Facsimile coding schemes consist of the basic facsimile coding scheme and optional facsimile coding schemes. They are defined in Section 2 and Sections 3 and 4 respectively.
- (2) Facsimile coding schemes are specified assuming that transmission errors are corrected by control procedure on lower level.
- (3) Basic facsimile coding scheme is the two-dimensional coding scheme which is in principle the same as the two-dimensional coding scheme of Group 3 facsimile specified in Recommendation T.4.
- (4) Optional facsimile coding schemes are specified not only for black and white images, but also for grey scale images and color images.
- (5) Facsimile coding control functions are used in facsimile user information in order to change facsimile parameters or to invoke the end of facsimile block. They are defined in Section 2.4.

## 2. Facsimile coding schemes and coding control functions for black and white images

### 2.1 General

#### 2.1.1

This Section specifies the facsimile coding schemes, and associated control functions for black and white images.

#### 2.1.2

Facsimile coding schemes consist of the basic facsimile coding scheme and optional coding schemes.

#### 2.1.3

The use of the optional facsimile coding schemes is subject to mutual agreement between terminals and shall be initiated by the appropriate procedural steps.

### 2.2 Basic facsimile coding scheme

### 2.2.1 Principle of coding scheme

This is a two-dimensional line-by-line coding method in which the position of each changing picture element on the current or coding line is coded with respect to the position of a corresponding reference element situated on either the coding line or the reference line which is immediately above the coding line. After the coding line has been coded, it becomes the reference line for the next coding line. The reference line for the first coding line in a page is an imaginary white line.

### 2.2.2 Definition of changing picture elements (see Figure 1)

A changing element is defined as an element whose "color" (i.e. black or white) is different from that of the previous element along the same scan line.

- $a_0$  : The reference or starting changing element on the coding line. At the start of the line  $a_0$  is set on an imaginary white changing element situated just before the first element on the line. During the coding of the coding line, the position of  $a_0$  is defined by previous coding mode. (See 2.2.3)
- $a_1$  : The next changing element to the right of  $a_0$  on the coding line.
- $a_2$  : The next changing element to the right of  $a_1$  on the coding line.
- $b_1$  : The first changing element on the reference line to the right of  $a_0$  and of opposite color to  $a_0$ .
- $b_2$  : The next changing element to the right of  $b_1$  on the reference line.

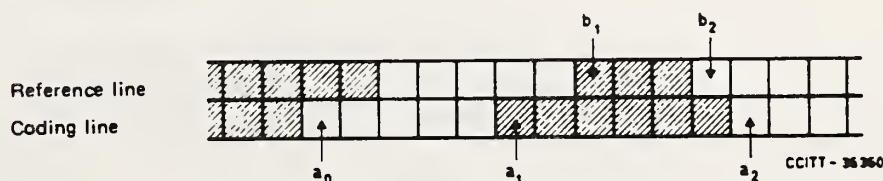


FIGURE 1

Changing picture elements

### 2.2.3 Coding modes

One of the three coding modes are chosen according to the coding procedure described in Section 2.2.4 to code the position of each changing element along the coding line. Examples of the three coding modes are given in Figure 2, 3 and 4.

#### a) Pass mode (see Figure 2)

This mode is identified when the position of  $b_2$  lies to the left of  $a_1$ .

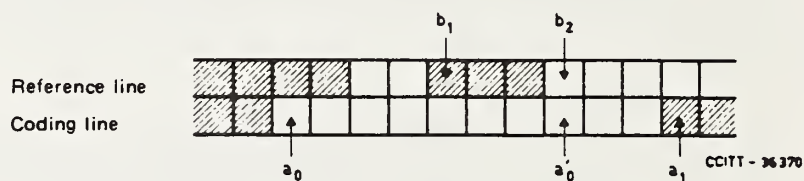


FIGURE 2

Pass mode

However, the site where  $b_2$  occurs just above  $a_1$ , as shown in Figure 3 is not considered as a pass mode.

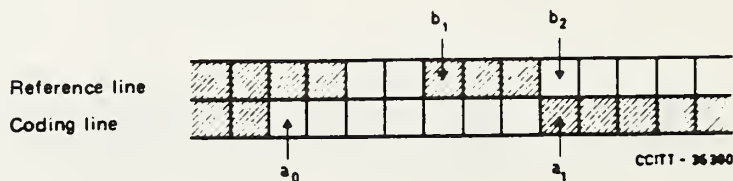


FIGURE 3

An example not corresponding to a Pass mode

b) Vertical Mode

When this mode is identified, the position of  $a_1$  is coded relative to the position of  $b_1$ . The relative distance  $a_1b_1$  can take on one of seven values  $V(0)$ ,  $V_R(1)$ ,  $V_R(2)$ ,  $V_R(3)$ ,  $V_L(1)$ ,  $V_L(2)$  and  $V_L(3)$ , each of which is represented by a separate code word. The subscripts R and L indicate that  $a_1$  is to the right or left respectively of  $b_1$ , and the number in brackets indicates the value of the distance  $a_1b_1$ . (See Figure 4)

c) Horizontal mode

When this mode is identified, both the run-lengths  $a_0a_1$  and  $a_1a_2$  are coded using the code words  $H + M(a_0a_1) + M(a_1a_2)$ .  $H$  is the flag code word 001 taken from the two-dimensional code table (Table 1).  $M(a_0a_1)$  and  $M(a_1a_2)$  are code words which represent the length and "color" of the runs  $a_0a_1$  and  $a_1a_2$  respectively and are taken from the appropriate white or black run-length code tables (Tables 2 and 3).

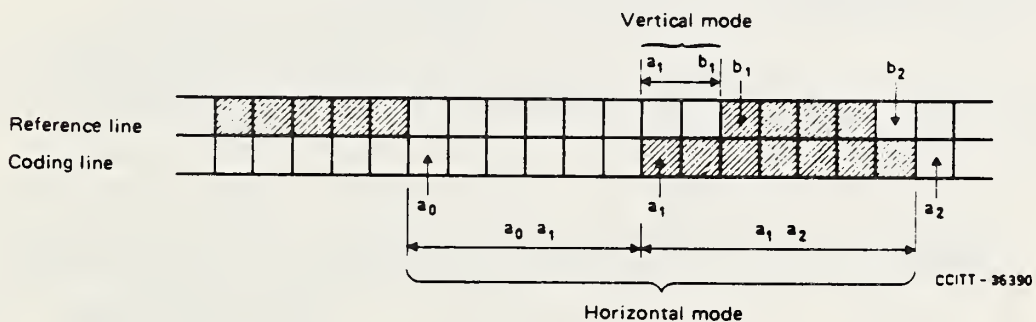


FIGURE 4

Vertical mode and horizontal mode

2.2.4 Coding procedures

The coding procedure identifies the coding mode that is to be used to code each changing element along the coding line. When one of the three coding modes has been identified according to Step 1 or Step 2 mentioned below, an appropriate code word is selected from the code table given in Table 1. The coding procedure is as shown in the flow diagram of Figure 5.



### Step 1

- i) If a pass mode is identified, this is coded using the word 0001 (Table 1). After this processing, picture element  $a_0$  just under  $b_2$  is regarded as the new starting picture element  $a_0$  for the next coding. (See Figure 2).
- ii) If a pass mode is not detected, then proceed to Step 2.

Note - It does not affect compatibility to restrict the use of pass mode in the encoder to a single pass mode. Variations of the algorithm which do not affect compatibility should be the subject of further study.

### Step 2

- i) Determine the absolute value of the relative distance  $a_1b_1$ .
- ii) If  $|a_1b_1| < 3$ , as shown in Table 1,  $a_1b_1$  is coded by the vertical mode, after which position  $a_1$  is regarded as the new starting picture element  $a_0$  for the next coding.
- iii) If  $|a_1b_1| > 3$ , as shown in Table 1, following horizontal mode code 001,  $a_0a_1$  and  $a_1a_2$  are respectively coded by one-dimensional run length coding.

Run lengths in the range of 0 to 63 pels are encoded with their appropriate Terminating code word of Table 2. Note that there is a different list of code words for black and white run lengths. Run lengths in the range of 64 to 2623 pels are encoded first by the Make-up code word representing the run length which is nearest, not longer, to that required. This is then followed by the Terminating code word representing the difference between the required run length and the run length represented by the Make-up code. Run lengths in the range of longer than or equal to 2624 pels are coded first by the Make-up code of 2560. If the remaining part of the run (after the first Make-up code of 2560), is 2560 pels or greater, additional Make-up code(s) of 2560 are issued until the remaining part of the run becomes less than 2560 pels. Then the remaining part of the run is encoded by Terminating code or by Make-up code plus Terminating code according to the range as mentioned above.

After this processing, position  $a_2$  is regarded as the new starting picture element  $a_0$  for the next coding.

Note - Coding examples are referred to in Section 4.2.5 in Recommendation T.4.



Note - Code M() of the horizontal mode represents the code words in Tables 2 and 3.

### 2.2.5 Processing the first and last picture element in a line

#### a) Processing the first picture element

The first starting picture element  $a_0$  on each coding line is imaginarily set at a position just before the first picture element, and is regarded as a white picture element (see Section 2.2.2).

The first run length on a line  $a_0a_1$  is replaced by  $a_0a_1 - 1$ . Therefore, if the first actual run is black and is deemed to be coded by horizontal mode coding, then the first code word  $M(a_0a_1)$  corresponds to an imaginary white run of zero length (see Figure 10 in Recommendation T.4, Example 5).

#### b) Processing the last picture element

The coding of the coding line continues until the position of the imaginary changing element situated just after the last actual element has been coded. This may be coded as  $a_1$  or  $a_2$ . Also, if  $b_1$  and/or  $b_2$  are not detected at any time during the coding of the line, they are positioned on the imaginary changing element situated just after the last actual picture element on the reference line.

### 2.3 Optional facsimile coding schemes for black and white images

#### 2.3.1 Uncompressed mode

Uncompressed mode is an optional coding scheme associated to basic facsimile coding scheme and is used to transmit the image information without data compression technique as shown in Table 4.

Extension code in Section 2.2.4 with the xxx bit set to 111 is used as an entrance code from basic coding scheme in Section 2.2 to uncompressed mode.

## 2.4 Facsimile coding control functions

### 2.4.1 Control functions for basic facsimile coding scheme

#### 2.4.1.1 End of facsimile block

The End of facsimile block (EOFB) code is added to the end of every coded facsimile block. The format of EOFB is as follows:

Format: 000000000001000000000001  
24 bits

#### 2.4.1.2 Pad bits

Pad bits may be used after the End of facsimile block code if it is necessary to align on octet boundaries or to a fixed block size. The format used is as follows:

Format: Variable Length string of 0s.

#### 2.4.1.3 Extension

Extension code is used to indicate the change from the current mode to another mode, e.g., another coding scheme.

Format: 0000001xxx

Where xxx = 111 indicates uncompressed mode which is specified in Section 3.2.1.

Further study is needed to define other unspecified xxx bit assignments and their use for any further extensions.

TABLE 1  
Code table

Mode	Elements to be coded		Notation	Code word
Pass	$b_1, b_2$		P	0001
Horizontal	$a_0 a_1, a_1 a_2$		H	$001 + M(a_0 a_1) + M(a_1 a_2)$ (see Note)
Vertical	$a_1$ just under $b_1$	$a_1 b_1 = 0$	$V(0)$	1
	$a_1$ to the right of $b_1$	$a_1 b_1 = 1$	$V_R(1)$	011
		$a_1 b_1 = 2$	$V_R(2)$	000011
		$a_1 b_1 = 3$	$V_R(3)$	0000011
	$a_1$ to the left of $b_1$	$a_1 b_1 = 1$	$V_L(1)$	010
		$a_1 b_1 = 2$	$V_L(2)$	000010
		$a_1 b_1 = 3$	$V_L(3)$	0000010
Extension				0000001xxx

Note — Code M( ) of the horizontal mode represents the code words in Tables 2 and 3

TABLE 2  
Terminating Codes

White run length	Code word	Black run length	Code word
0	00110101	0	0000110111
1	0001111	1	010
2	0111	2	11
3	1000	3	10
4	1011	4	011
5	1100	5	0011
6	1110	6	0010
7	1111	7	00011
8	10011	8	000101
9	10100	9	000100
10	00111	10	0000100
11	01000	11	0000101
12	001000	12	0000111
13	000011	13	00000100
14	110100	14	00000111
15	110101	15	000011000
16	101010	16	0000010111
17	101011	17	0000011000
18	0100111	18	0000001000
19	0001100	19	00001100111
20	0001000	20	00001101000
21	0010111	21	00001101100
22	0000011	22	00000110111
23	0000100	23	00000101000
24	0101000	24	00000010111
25	0101011	25	00000011000
26	0010011	26	000011001010
27	0100100	27	000011001011
28	0011000	28	000011001100
29	00000010	29	000011001101
30	00000011	30	000001101000
31	00011010	31	000001101001
32	00011011	32	000001101010
33	00010010	33	000001101011
34	00010011	34	000011010010
35	00010100	35	000011010011
36	00010101	36	000011010100
37	00010110	37	000011010101
38	00010111	38	000011010110
39	00101000	39	000011010111
40	00101001	40	000001101100
41	00101010	41	000001101101
42	00101011	42	000011011010
43	00101100	43	000011011011
44	00101101	44	000001010100
45	00000100	45	000001010101
46	00000101	46	000001010110
47	00001010	47	000001010111
48	00001011	48	000001100100
49	01010010	49	000001100101
50	01010011	50	000001010010
51	01010100	51	000001010011
52	01010101	52	000000100100
53	00100100	53	000000110111
54	00100101	54	000000111000
55	01011000	55	000000100111
56	01011001	56	000000101000
57	01011010	57	000001011000
58	01011011	58	000001011001
59	01001010	59	000000101011
60	01001011	60	000000101100
61	00110010	61	000001011010
62	00110011	62	000001100110
63	00110100	63	000001100111

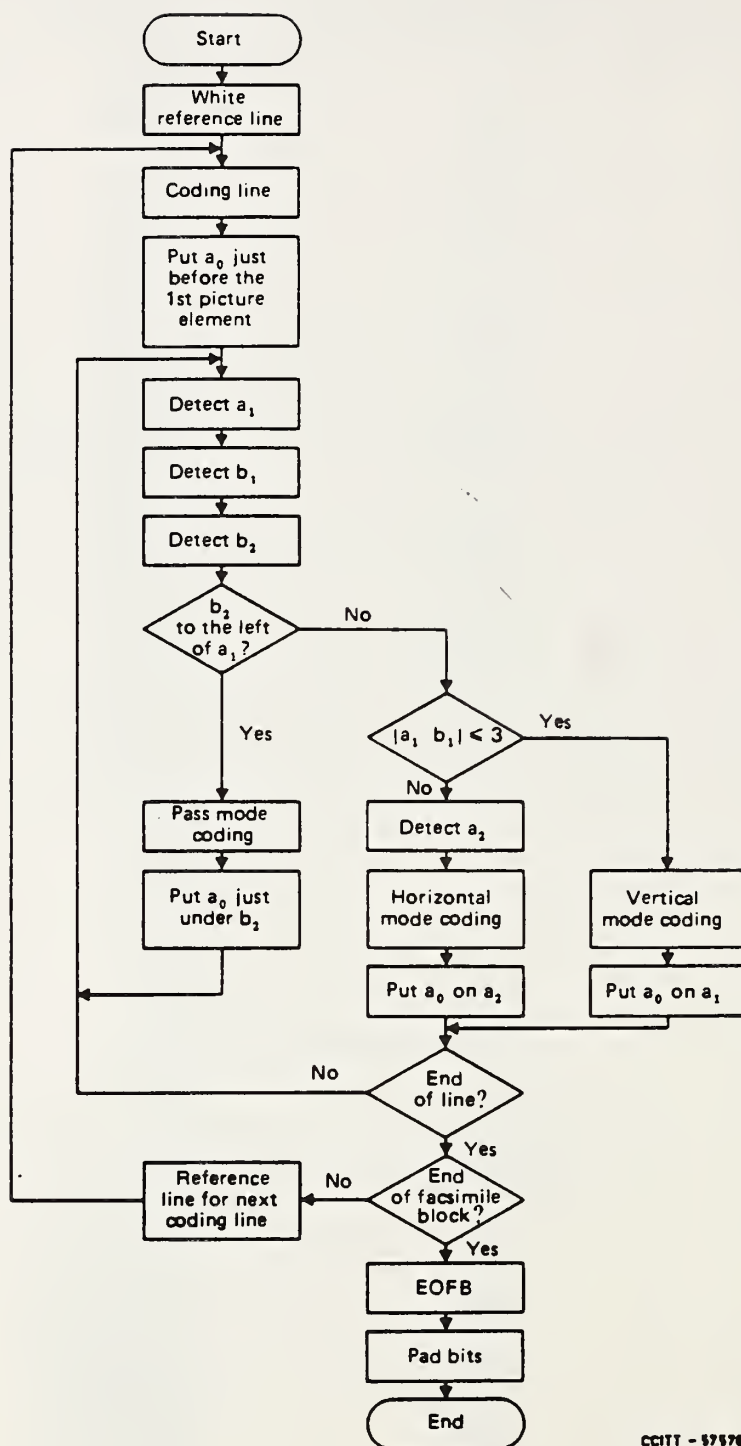


TABLE 3  
Make-up codes between 64 and 1728

White run lengths	Code word	Black run lengths	Code word
64	11011	64	0000001111
128	10010	128	000011001000
192	010111	192	000011001001
256	0110111	256	000001011011
320	00110110	320	000000110011
384	00110111	384	000000110100
448	01100100	448	000000110101
512	01100101	512	0000001101100
576	01101000	576	0000001101101
640	01100111	640	0000001001010
704	011001100	704	0000001001011
768	011001101	768	0000001001100
832	011010010	832	0000001001101
896	011010011	896	0000001110010
960	011010100	960	0000001110011
1024	011010101	1024	0000001110100
1088	011010110	1088	0000001110101
1152	011010111	1152	0000001110110
1216	011011000	1216	0000001110111
1280	011011001	1280	0000001010010
1344	011011010	1344	0000001010011
1408	011011011	1408	0000001010100
1472	010011000	1472	0000001010101
1536	010011001	1536	0000001011010
1600	010011010	1600	0000001011011
1664	011000	1664	0000001100100
1728	010011011	1728	0000001100101

Make-up codes between 1792 and 2560

Run length (black and white)	Make-up codes
1792	00000001000
1856	00000001100
1920	00000001101
1984	000000010010
2048	000000010011
2112	000000010100
2176	000000010101
2240	000000010110
2304	000000010111
2368	000000011100
2432	000000011101
2496	000000011110
2560	000000011111



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FIGURE 5  
Coding flow diagram

TABLE 4  
Uncompressed mode code words

Entrance code to uncompressed mode	Basic coding scheme : 0000001111	
Uncompressed mode code	<i>Image pattern</i>	<i>Code word</i>
	1	1
	01	01
	001	001
	0001	0001
	00001	00001
	00000	000001
Exit from uncompressed mode code	0	0000001T
	00	00000001T
	000	000000001T
	0000	0000000001T
	00000	00000000001T

T denotes a tag bit which tells the colour of the next run (black = 1, white = 0).





This standard has been adopted for Federal Government use.

Details concerning its use within the Federal Government are contained in Federal Information Processing Standards Publication 150, Facsimile Coding Schemes and Coding Control Functions for Group 4 Facsimile Apparatus. For a complete list of the publications available in the Federal Information Processing Standards Series, write to the Standards Processing Coordinator (ADP), National Institute of Standards and Technology, Gaithersburg, MD 20899.

